

FIG. 1

Sample No.	Fe ₂ O ₃ (mol%)	MnO (mol%)	ZnO (mol%)	NiO (mol%)	Bs (mT)	Pcv (kW/m ³)	B.Temp. .(°C)	μ i	Additives	Sintering temp. (°C)	Partial pressure of oxygen (%)
Comp. ex. 1	60.0	21.0	15.0	4.0	467	1410	60	824	SiO ₂ :100ppm CaCO ₃ :1500ppm Nb ₂ O ₅ :200ppm *Weight ratio of SiO ₂ content to CaCO ₃ content = 0.07	1350	1
1	63.0	17.0	18.0	2.0	494	661	100	1059			
2	65.0	17.0	16.0	2.0	515	897	100	784			
3	67.0	18.5	14.0	0.5	505	988	100	702			
Comp. ex. 2	70.0	14.5	15.0	0.5	463	2675	100	389			
Comp. ex. 3	67.0	21.0	10.0	2.0	475	1225	80	742			
4	65.0	19.0	14.0	2.0	519	964	80	928			
5	64.0	16.5	18.0	1.5	501	770	100	901			
Comp. ex. 4	65.0	13.5	21.0	0.5	474	1045	140	571			
6	67.0	18.5	14.0	0.5	505	988	100	702	SiO ₂ :60ppm, CaCO ₃ :700ppm, Nb ₂ O ₅ :250ppm,	1300	1
7	64.0	18.0	16.0	2.0	500	731	80	1074			
8	64.0	18.0	14.0	4.0	515	943	100	819			
Comp. ex. 5	64.0	16.0	14.0	6.0	512	1358	120	584			
Prior art ex.1	70.0	15.0	15.0	-	470	3207	140	220			
Prior art ex.2	60.0	25.0	15.0	-	456	1431	20	1300	SiO ₂ :100ppm, CaCO ₃ :700ppm, Ta ₂ O ₅ :300ppm	1300	1
Prior art ex.3	70.0	10.0	20.0	-	468	2618	140	250			
Prior art ex.4	70.0	10.0	20.0	-	503	1846	100	490			
In nitrogen										1250	

<Remarks>

Bs : Saturation magnetic flux density (at 100°C) Pcv : Core loss at bottom temperature (at 100 kHz, 200 mT)
B.Temp. : Bottom temperature μ i: Initial permeability (at 25°C)

FIG. 2

Sample No.	First additives		Weight ratio of SiO ₂ content to CaCO ₃ content	Bs (mT)	Pcv (kW/m ³)	B.Temp. (°C)	μi
	SiO ₂ (ppm)	CaCO ₃ (ppm)					
9	100	1500	0.07	498	665	100	1182
10	150	1500	0.10	496	689	100	1089
11	200	1500	0.13	505	703	100	1002
Comp. ex.6	300	1500	0.20	507	1241	100	601
12	150	1000	0.15	493	830	100	971
13	150	2000	0.08	495	746	100	1083
Comp. ex.7	150	3000	0.05	492	1046	100	874
<Remarks>							
Sintering : at 1350°C, partial pressure of oxygen 1%							
Bs : Saturation magnetic flux density (at 100°C) Pcv: Core loss at bottom temperature (at 100 kHz, 200 mT)							
B.Temp. : Bottom temperature							
constituents : Fe ₂ O ₃ : 63 mol% MnO : 17.5 mol%							
μi : Initial permeability (at 25°C) NiO: 2 mol%							
Additive : Nb ₂ O ₅ :200ppm							

Sample No.	Additive	Additive amount (ppm)	Bs (mT)	Pcv (kW/m ³)	B.Temp. (°C)	μ i	Remarks	
14	Nb ₂ O ₅	100	508	911	100	785	Second additives	
15		200	507	812	100	875		
16		300	505	1109	100	729		
Comp. ex. 8		500	510	1253	100	782		
17	ZrO ₂	200	494	832	100	1000		
18		500	505	795	100	942		
19		800	514	1025	100	751		
20	Ta ₂ O ₅	200	494	1011	100	892		
21		500	508	810	100	980		
22	In ₂ O ₅	200	496	1165	80	900		
23		500	502	1037	100	888		
24	Ga ₂ O ₅	200	493	1105	100	809		
25		500	498	1067	100	866		
26	V ₂ O ₅	200	510	1126	100	761		Fourth additives
27		500	513	1070	100	583		
28	GeO ₂	200	494	827	100	936		
29		500	497	977	100	851		

<Remarks>

Sintering : at 1350°C, partial pressure of oxygen 1%

Bs : Saturation magnetic flux densit Pcv : Core loss at bottom temperature
(at 100°C)

FIG. 4

Sample No.	Third additives		Bs (mT)	Pcv (kW/m ³)	B.Temp. (°C)	μi
	SnO ₂ (ppm)	TiO ₂ (ppm)				
30	1000	0	496	1049	100	821
31	5000	0	491	1103	100	690
32	0	1000	498	1188	100	695
33	0	3000	493	995	100	680
34	0	5000	485	930	100	680

<Remarks>

Sintering : at 1350°C, partial pressure of oxygen 1%

Bs : Saturation magnetic flux density (at 100°C)

Pcv : Core loss at bottom temperature (at 100kHz, 200mT)

B.Temp. : Bottom temperature

Other : Fe₂O₃ : 64.0 mol% MnO: 17.5 mol% μi : Initial permeability (at 25°C)
 constituents NiO: 2.0 mol% CaCO₃: 1500 ppm ZnO: 16.5 mol%

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07

FIG. 5

Sample No.	Main constituents (mol%)	Additives (ppm)	MoO ₃ (ppm)	P (ppm)	Sintering temp. (°C)	Partial pressure of oxygen (%)	Bs (mT)	P _c v (kW/m ³)	B.Temp. (°C)	μ _i	Relative density (%)	Mean grain size (μm)
35			—	—			489	746	100	1390	96.0	10
36			100	—			496	813	100	847	97.1	—
37			200	—	1300	0.5	508	944	100	830	97.4	—
38	Fe ₂ O ₃ : 64.0,	SiO ₂ :100, CaCO ₃ :1500, Nb ₂ O ₅ :200	—	17			497	733	100	919	—	—
39	MnO: 17.5,		—	27			499	755	100	910	—	—
40	ZnO: 16.5,		—	—	1330	0.8	502	827	100	879	96.9	13
41	NiO: 2.0		—	—	1350	1.0	506	840	100	855	97.7	16
42			—	—	1380	1.4	517	1022	100	693	98.1	20
43			—	—	1400	1.7	502	1189	100	593	97.4	25

<Remarks>
Bs : Saturation magnetic flux density (at 100°C) P_cv : Core loss at bottom temperature (at 100kHz, 200mT)
B.Temp. : Bottom temperature μ_i : Initial permeability (at 25°C)

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07

FIG. 6

Sample No.	Fourth additive	Additive amount (ppm)	Relative density (%)	Bs (mT)	P _{cv} (kW/m ³)	B.Temp. (°C)	μ _i	Sintering temp. (°C)	Partial pressure of oxygen (%)
35	None	—	96.0	489	746	100	1390	1300	0.5
44	In terms of P (Ca ₃ (PO ₄) ₂)	10	96.8	497	753	100	919		
45		20	96.6	499	755	100	910		
36		100	97.1	496	813	100	847		
37	MoO ₃	200	97.4	508	944	100	830		
46		500	97.2	499	964	100	974		
47		100	96.2	499	788	100	1002		
48	V ₂ O ₅	200	96.5	499	760	100	992		
49		500	96.2	496	888	100	952		
50		200	95.9	494	776	100	962		
51	GeO ₂	500	95.4	494	780	100	973		
52		200	95.8	494	795	100	980		
53	Bi ₂ O ₃	500	96.5	502	981	90	988		
54		200	95.9	496	747	100	1086		
55		500	97.0	497	798	100	961		
56		1000	97.3	507	794	100	1100		
57		2000	97.3	505	913	100	945		

<Remarks>

Bs : Saturation magnetic flux density (at 100°C)

B.Temp. : Bottom temperature

Other : Fe₂O₃ : 64.0 mol%

constituents NiO: 2.0 mol%

Nb₂O₅:200ppm

P_{cv} : Core loss at bottom temperature (at 100kHz, 200mT)

μ_i : Initial permeability (at 25°C)

ZnO: 16.5 mol%

CaCO₃: 1500 ppm

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07

FIG. 7

Sample No.	Fe ₂ O ₃ (mol%)	MnO (mol%)	ZnO (mol%)	NiO (mol%)	MoO ₃ (fourth additive) (ppm)	Sintering temp. (°C)	Partial pressure of oxygen (%)	Relative density (%)	B _s (mT)	P _{cv} (kW/m ³)	B.Temp. (°C)	μ _i
58	64.0	16.0	20.0	—	—	1350	1.0	96.2	467	736	100	1103
59	64.0	16.0	20.0	—	100			97.4	484	1065	110	866
60	66.0	17.0	17.0	—	—	1300	0.5	96.7	492	919	110	758
61	66.0	17.0	17.0	—	100			97.4	511	1019	110	711
<p><Remarks></p> <p>B_s : Saturation magnetic flux density (at 100°C) P_{cv} : Core loss at bottom temperature (at 100 kHz, 200 mT)</p> <p>B.Temp. : Bottom temperature μ_i : Initial permeability (at 25°C)</p> <p>Additives : SiO₂: 100 ppm CaCO₃: 1500 ppm Nb₂O₅: 200 ppm</p> <p>*Weight ratio of SiO₂ content to CaCO₃ content = 0.07</p>												

FIG. 8

Sample No.	Fe ₂ O ₃ (mol%)	MnO (mol%)	ZnO (mol%)	NiO (mol%)	Sintering temp. (°C)	pressure of oxygen (%)	B _s (mT)	P _{c_v} (kW/m ³)	B.Temp. (°C)	μ _i
62						2.0	496	687	100	1129
63						1.5	498	675	100	1132
64	63.0	17.5	17.5	2.0	1350	1.0	498	673	100	1209
65						0.5	495	766	100	1074
66						0.2	498	948	80	1073

<Remarks>

B_s : Saturation magnetic flux density (at 100°C) P_{c_v} : Core loss at bottom temperature (at 100kHz, 200mT)

B.Temp. : Bottom temperature μ_i : Initial permeability (at 25°C)

Additives : SiO₂: 100 ppm CaCO₃: 1500 ppm Nb₂O₅: 200 ppm

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07

FIG. 9

Sample No.	Fe ₂ O ₃ (mol%)	MnO (mol%)	ZnO (mol%)	LiO _{0.5} (mol%)	Bs (mT)		P _c v (kW/m ³)					B.Temp. (°C)	μ i	
					RT	100°C	25°C	40°C	60°C	80°C	100°C			120°C
Comp. ex.9	64.0	20.0	16.0	—	592	487	786	654	893	1070	1191	1252	40	1964
67	64.0	19.0	16.0	1.0	591	501	1733	1372	883	861	945	1053	80	987
68	64.0	18.0	16.0	2.0	579	501	2182	1883	1506	1112	1006	1009	100	737
Comp. ex.10	64.0	16.0	16.0	4.0	545	487	2910	2694	2425	2162	2033	1866	120	481

<Remarks>

Sintering: at 1350°C, partial pressure of oxygen 1%

Bs: Saturation magnetic flux density (at 100°C)

RT: Room temperature

P_cv: Core loss (at 100 kHz, 200 mT)

B.Temp.: Bottom temperature

μ i: Initial permeability (at 25°C)

Additives : SiO₂:100ppm CaCO₃:1500ppm Nb₂O₅:200ppm

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07

FIG. 10

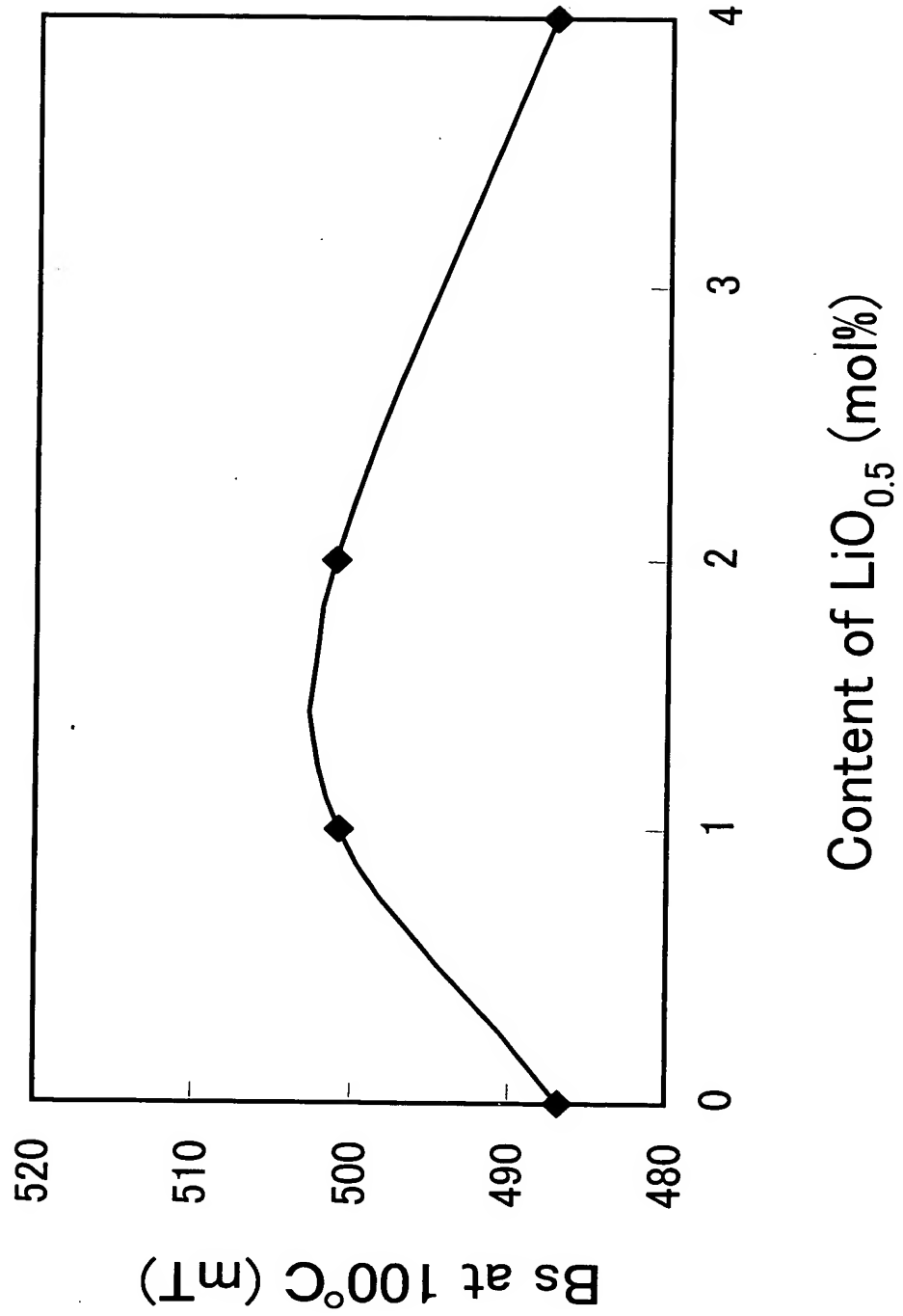


FIG. 11

Sample No.	Fe ₂ O ₃ (mol%)	MnO (mol%)	ZnO (mol%)	LiO _{0.5} (mol%)	Bs (mT)	P _{cvt} (kW/m ³)	B.Temp. (°C)	μ i	Additives	Sintering temp. (°C)	Partial pressure of oxygen (%)
Comp. ex.11	60.0	22.5	15.0	2.5	457	1538	60	792			
69	62.0	18.0	18.0	2.0	487	678	80	1147	SiO ₂ :100ppm		
68	64.0	18.0	16.0	2.0	501	1006	100	737	CaCO ₃ :1500ppm		
70	67.0	18.5	14.0	0.5	507	1052	100	713	Nb ₂ O ₅ :200ppm		
Comp. ex.12	70.0	14.5	15.0	0.5	466	3111	100	370		1350	1
Comp. ex.13	67.0	21.0	11.0	1.0	479	1355	80	559	*Weight ratio of SiO ₂ content to CaCO ₃ content = 0.07		
71	65.0	19.0	14.0	2.0	515	1108	100	789			
72	64.0	17.0	18.0	1.0	495	842	100	813			
Comp. ex.14	65.0	13.5	21.0	0.5	475	1090	140	521			
Prior art ex.1	70.0	15.0	15.0	-	470	3207	140	220	SiO ₂ :60ppm, CaCO ₃ :700ppm,	1300	1
Prior art ex.2	60.0	25.0	15.0	-	456	1431	20	1300	Nb ₂ O ₅ :250ppm, Ta ₂ O ₅ :50ppm		
Prior art ex.3	70.0	10.0	20.0	-	468	2618	140	250	SiO ₂ :100ppm,	1300	1
Prior art ex.4	70.0	10.0	20.0	-	503	1846	100	490	CaCO ₃ :700ppm, Ta ₂ O ₅ :300ppm	1250	In nitrogen
<Remarks>											
Bs: Saturation magnetic flux density (at 100°C)						P _{cvt} : Core loss at bottom temperature (at 100 kHz, 200 mT)					
B.Temp.: Bottom temperature						μ i: Initial permeability (at 25°C)					

Sample No.	First additives		Weight ratio of SiO ₂ content to CaCO ₃ content	Bs (mT)	Pcv (kW/m ³)	B.Temp. (°C)	μi
	SiO ₂ (ppm)	CaCO ₃ (ppm)					
73	100	1500	0.07	501	861	80	987
74	200	1500	0.13	507	934	80	887
75	150	2000	0.08	498	966	80	914

<Remarks>

Sintering: at 1350°C, partial pressure of oxygen 1% Pcv: Core loss at bottom temperature
 Bs: Saturation magnetic flux density (at 100°C) (at 100 kHz, 200 mT)
 B.Temp.: Bottom temperature *μi : Initial permeability (at 25°C)*

Main constituents : Fe₂O₃ : 64 mol%
 MnO : 19 mol%
 LiO_{0.5}: 1 mol%
ZnO:16 mol%

Additive : Nb₂O₅:200ppm

FIG. 13

Sample No.	Additive	Additive amount (ppm)	Bs (mT)	Pcv (kW/m ³)	B.Temp. (°C)	μ i	Remarks
76	Nb ₂ O ₅	200	501	861	80	987	Second additives
77	ZrO ₂	500	499	850	80	1041	
78	Ta ₂ O ₅		500	865	80	1077	
79	In ₂ O ₅		495	1117	80	1008	
80	Ga ₂ O ₅		492	1092	80	985	
81	SnO ₂	1000	489	1099	80	927	Third additives
82	TiO ₂	3000	485	1048	80	806	
83	GeO ₂	200	492	886	80	997	Fourth additives
84	V ₂ O ₅	500	510	1065	80	712	
<Remarks>							
Sintering: at 1350°C, partial pressure of oxygen 1%			Pcv: Core loss at bottom temperature (at 100 kHz, 200 mT)				
Bs: Saturation magnetic flux density (at 100°C)			μ i: Initial permeability (at 25°C)				
B.Temp.: Bottom temperature							
Other constituents : Fe ₂ O ₃ : 64 mol%			MnO:19 mol%		ZnO:16 mol%		
SiO ₂ : 100 ppm			CaCO ₃ : 1500 ppm		Nb ₂ O ₅ :200ppm		
					LiO _{0.5} : 1 mol%		
*Weight ratio of SiO ₂ content to CaCO ₃ content = 0.07							

FIG. 14

Sample No.	Fourth additive	Additive amount (ppm)	Relative density (%)	Mean grain size (μm)	B _s (mT)	P _c v (kW/m ³)	B.Temp. (°C)	μ_i	Sintering temp. (°C)	Partial pressure of oxygen (%)
85	None	—	96.2	10	482	777	80	1418		
86	In terms of P (Ca ₃ (PO ₄) ₂)	20	96.8	16	494	790	80	1027		
87	MoO ₃	200	97.4	14	504	987	80	945		
88	GeO ₂	500	96.3	11	487	798	80	1065	1300	0.5
89	Bi ₂ O ₃	500	96.7	17	495	1011	80	1054		
90	Sb ₂ O ₃	1000	97.2	12	500	828	80	1195		
91	V ₂ O ₅	500	96.5	15	492	923	80	1061		
84	V ₂ O ₅	500	—	—	510	1065	80	712	1350	1

<Remarks>

B_s: Saturation magnetic flux density (at 100°C)
B.Temp.: Bottom temperature
P_cv: Core loss at bottom temperature (at 100 kHz, 200 mT)
 μ_i : Initial permeability (at 25°C)

Other constil : Fe₂O₃ : 64 mol% MnO : 19 mol% LiO_{0.5}: 1 mol%
SiO₂: 100 ppm CaCO₃: 1500 ppm Nb₂O₅:200ppm

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07

FIG. 15

Sample No.	Fe ₂ O ₃ (mol%)	MnO (mol%)	ZnO (mol%)	NiO (mol%)	LiO _{0.5} (mol%)	Bs (mT)	P _{cv} (kW/m ³)	B.Temp. (°C)	μ _i	Additives	Sintering temp. (°C)	Partial pressure of oxygen (%)
Comp. ex.15	60.0	22.0	15.0	1.0	2.0	462	1433	80	831	SiO ₂ :100ppm CaCO ₃ :1500ppm Nb ₂ O ₅ :200ppm *Weight ratio of SiO ₂ content to CaCO ₃ content = 0.07	1350	1
92	63.0	17.5	18.0	1.0	0.5	494	714	100	1155			
93	67.0	19.5	12.5	0.5	0.5	507	1167	80	803			
Comp. ex.16	70.0	14.5	14.5	0.5	0.5	475	2971	100	350			
Comp. ex.17	67.0	21.0	10.0	1.0	1.0	479	1303	100	675			
94	65.0	19.0	14.0	1.0	1.0	510	951	100	890			
95	64.0	16.5	18.0	0.5	1.0	504	901	120	732			
Comp. ex.18	64.5	13.5	21.0	0.5	0.5	470	1125	140	489			
93	67.0	19.5	12.5	0.5	0.5	507	1167	80	803			
96	64.0	17.8	14.0	4.0	0.2	512	976	100	862			
Comp. ex.19	64.0	16.0	13.5	6.0	0.5	504	1443	120	604			
93	67.0	19.5	12.5	0.5	0.5	507	1167	80	803	SiO ₂ :60ppm, CaCO ₃ :700ppm, Nb ₂ O ₅ :250ppm,Ta ₂ O ₅ :50ppm	1300	1
97	64.0	17.5	16.0	0.5	2.0	504	1026	100	799		1300	1
Comp. ex.20	64.0	17.5	14.0	0.5	4.0	481	1616	140	520		1250	In nitrogen
Prior art ex.1	70.0	15.0	15.0	-	-	470	3207	140	220		1350	In nitrogen (2% of oxygen)
Prior art ex.2	60.0	25.0	15.0	-	-	456	1431	20	1300	SiO ₂ :100ppm, CaCO ₃ :700ppm, Ta ₂ O ₅ :300ppm	1300	1
Prior art ex.3	70.0	10.0	20.0	-	-	468	2618	140	250			
Prior art ex.4	70.0	10.0	20.0	-	-	503	1846	100	490	-	1350	In nitrogen (2% of oxygen)
Prior art ex.5	54.0	25.0	11.0	10.0	-	-	-	240	-			
Prior art ex.6	54.0	25.0	11.0	-	10 (Li ₂ O)	-	-	250	-			
<Remarks>												
Bs: Saturation magnetic flux density (at 100°C) P _{cv} : Core loss at bottom temperature (at 100 kHz, 200 mT)												
B.Temp. : Bottom temperature μ _i : Initial permeability (at 25°C)												

FIG. 17

Sample No.	Additive	Additive amount (ppm)	Bs (mT)	Pcv (kW/m ³)	B.Temp. (°C)	μi	Remarks
101	Nb ₂ O ₅	200	510	951	100	890	Second additives
102	ZrO ₂	500	502	901	100	1017	
103	Ta ₂ O ₅		508	963	100	949	
104	In ₂ O ₅		505	1117	100	910	
105	Ga ₂ O ₅		500	1211	100	845	
106	SnO ₂	1000	499	1089	100	844	Third additives
107	TiO ₂	3000	494	1045	100	789	
108	GeO ₂	200	499	939	100	952	Fourth additives
109	V ₂ O ₅	500	513	1201	100	703	

<Remarks>

Sintering : at 1350°C, partial pressure of oxygen 1% Pcv: Core loss at bottom temperature
Bs : Saturation magnetic flux density (at 100°C) (at 100kHz, 200mT)
B.Temp. : Bottom temperature μi : Initial permeability (at 25°C)

Other constituents : Fe₂O₃ : 65 mol% MnO:19 mol% ZnO:14 mol%
NiO: 1 mol% LiO_{0.5}: 1 mol%
SiO₂: 100 ppm CaCO₃: 1500 ppm Nb₂O₅:200ppm

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07

FIG. 18

Sample No.	Fourth additive	Additive amount (ppm)	Relative density (%)	Mean grain size (μm)	B _s (mT)	P _c v (kW/m ³)	B.Temp. (°C)	μ_i	Sintering temp. (°C)	Partial pressure of oxygen (%)
110	None	—	95.5	10	488	898	100	1343		
111	In terms of P (Ca ₃ (PO ₄) ₂)	20	96.8	15	501	912	100	970		
112	MoO ₃	200	97.3	15	510	1086	100	869		
113	GeO ₂	500	95.6	12	494	927	100	1023	1300	0.5
114	Bi ₂ O ₃	500	96.1	17	501	1137	90	1039		
115	Sb ₂ O ₃	1000	97.3	13	508	978	100	1086		
116	V ₂ O ₅	500	96.0	14	496	1050	100	1052		
109	V ₂ O ₅	500	—	—	513	1201	100	703	1350	1

<Remarks>

B_s : Saturation magnetic flux density (at 100°C) P_cv : Core loss at bottom temperature (at 100 kHz, 200 mT)
B.Temp. : Bottom temperature μ_i : Initial permeability (at 25°C)

Other constituents : Fe₂O₃ : 65 MnO : 19 mol% ZnO : 14 mol%
NiO : 1 mol% Li₂O : 1 mol%
SiO₂ : 100 ppm CaCO₃ : 1500 ppm Nb₂O₅ : 200 ppm

*Weight ratio of SiO₂ content to CaCO₃ content = 0.07